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Li Hsieh

Report on the Wei-Peh irrigation work, Shensi

Sianfu, Shensi

1923

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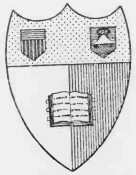

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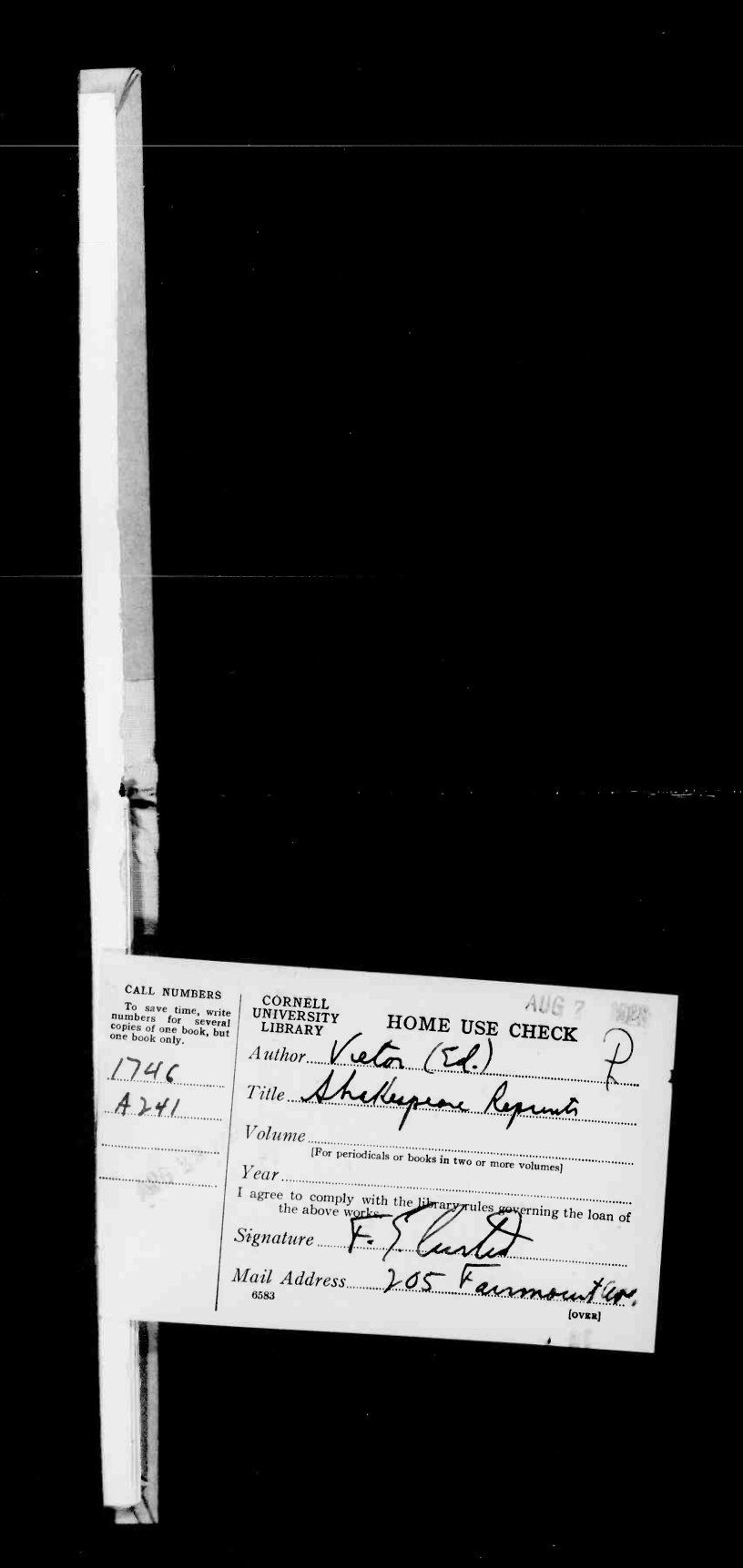

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By Li Hsieh

Engineer-in-chief, Shensi Conservancy Board,

SIANFU, SHENSI

1923

Peking Leader Press

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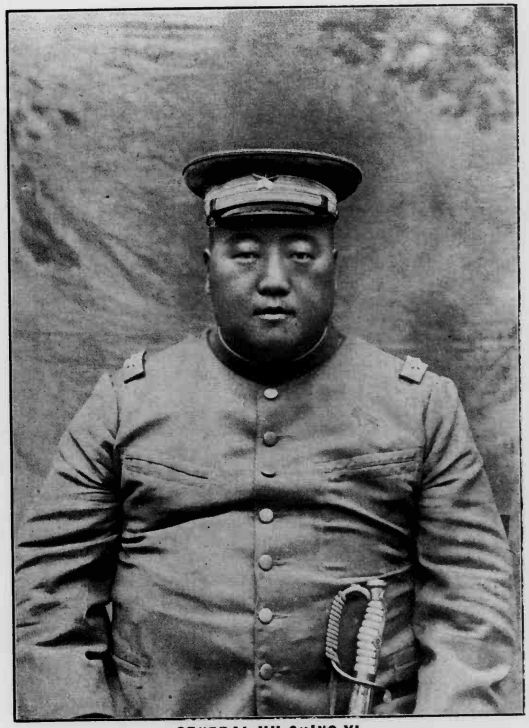

GENERAL HU CHING-YI

Honorable Chairman of the Board of Trustees of the Wei Peh Irrigation Work.

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Chief Engineer, Wei-Peh Irrigation Scheme.

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REPORT OF WEI-PEH IRRIGATION WORK, SHENSI.

By Li Hsieh

Engineer-in-Chief, Shensi Conservancy Board

I. Introduction and History of the Irrigation Work in Wei-peh District, Shensi.

The Wei-peh plain of Shensi lies north of the Wei River and west of the Yellow River, an area over 300 li in length and not less than 80 li in width. It is formed according to Herr Ferdinand v. Richthofen, by lake deposition. As an ancient lake, containing saline water, it had been filled up gradually by marine loess and materials transported by wind. In the region between the district of Weinan and the district of Pucheng, there is still an area about 50 li long and 10 li wide covered with salty soil. Wells dug within this plain give mostly salty water. Through thousands of years of cultivation this plain had become a fertile land and it produces more wheat and cotton than any other district in the province. As a matter of fact the crops produced on this plain not only supply all districts surrounding Sianfu but also help to feed Honan and Shansi Provinces.

The land of this plain is of a semi-arid character and, if there be no other help, the harvests depend chiefly upon rain fall. Unfortunately dry seasons occur frequently (on an average once in five years) and a great drought occurs on an average of once in ten years. From Chinese historical records, we learn that from the Shang dynasty (1390 B.C.) down to the present time there have been 162 famine years, of which.

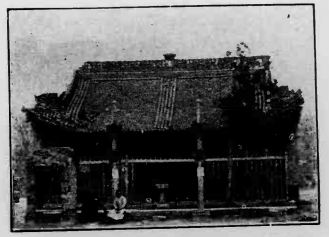
15 were due to innundation,
12 were due to locusts,
7 were due to locusts, and drought,
1 was due to locusts, and innundation,
127 were due to drought.

The above statistics show that for every twenty years there was a famine. However from the begining of the Ming dynasty to the present (1363-1923 A.D.) the intervals have been shortened and famine has occurred once in every ten years instead.

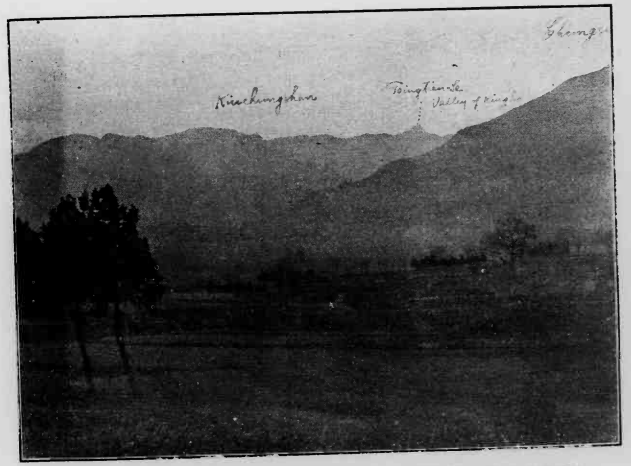
To relieve the Province from the danger of famine due to drought no better measure can be taken than to establish irrigation works. The sources of water supply for irrigation works may be either from rivers or from underground water; but on account of the great depth as well as of the salty contents, the latter source can hardly be used to serve the purpose. Therefore we can only direct our attention to the former.

Within the plain of Wei-peh, there are five other rivers running into the Wei, namely the Lo, the Shechuan, the Tsing, the Yeh, (which joins the Tsing in the lower stream), and the King. Three of them have frequently been and are still used for irrigation purposes. During the Han dynasty attempts were made to use the Lo for irrigation work, but these failed because its valley was too deep and the location too low in the lower portion of the river. The King River alone has been used for irrigation with good success. The first irrigation work accompilshed on this river was towards the end of the Chou dynasty by Cheng Kou, an engineer of the kingdom of Han. Incidently that was also the first irrigation work ever done in China. Concerning this work there is an interesting story that may be given here. Being afraid of the powerful kingdom of Tsin, the king of Han sent his engineer, Cheng Kou, to persuade the king of Tsin to undertake the great enterprise of irrigation work so as to reduce the energy of Tsin from making trouble for him. But when the work was completed, the result was contrary to his expectations. Our interest is, however to remember that this engineering work distinguished Chen Kou as the first irrigation engineer of China.

The Cheng Kou Canal ran from the Mouth of King Valley (out of the Tsungshan Hill) eastward along the northern hills, crossing the Yeh, Tsing and Shechuan rivers and irrigated a district of more than four million mou. The Cheng Kou Dam must have been built very substantially and high, to store sufficient water for irrigating so wide an area. It is stated that



1. A temple in the village before Chungshan. B.M.O. assumed 500.00 m. above sea level is beneath the foot of the standing man and cut into the stone.



2. General front view of the Chungshan and Kinchungshan, between these hills the river King is running.

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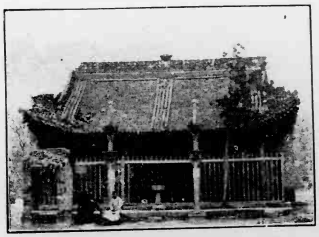

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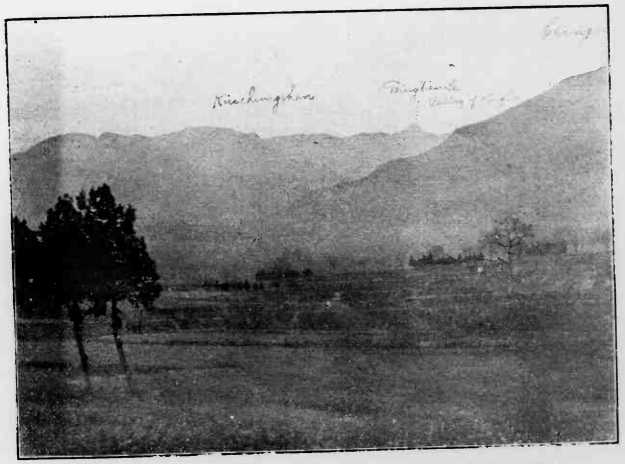


2. General front view of the Chungshan and Kinchungshan, between these hills the river King is running.

in view of its specially strong foundation the Cheng Kou Dam was built on natural rock ridges in the river bed by baskets filled with stones. There were 120 rows of such baskets and each row contained more than 100 baskets. Supposing each row had a dimension of 10 by 10 feet, the crown of such a dam must have had a length of more than 1000 feet and a height of not less than 100 feet, according to the formation of King Valley to-day.

One hundred years later, the C heng Kou work was destroyed and another one built, but on a smaller scale. The new work, the so called Pe Kung Canal, irrigated an area of about 450,000 mou only. Why this later canal did not follow the projection of the previous one may be attributed to the fact, that after the destruction of the former dam the river bed had been deepened and the natural foundation of rock ridges fallen; therefore Pe Kung could then build a dam only high enough to divert the water from King River to enter the canal. The area irrigated by this canaf was limited to the south of the Tsing River only. However, both Cheng Kuo and Pe Kung deserved the credit as early Chinese irrigation engineers.

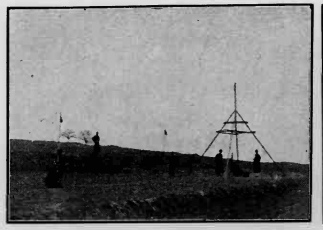
The Pe Kung Canal lasted a period, of over one thousand years, and the work was so well done that afterwards there was only little needed repairing at certain parts of the canal. The Pe Kung Canal was destroyed in the Sung dynasty, one thousand years after its completion. Then the FungLi Canal was constructed to take its place. When the Fung-Li work was out of existence, the Wong Yue-Se Canal was constructed in the Yuan Dynasty (1320 A. D.) and the Kuang Hui Canal in the Ming Dynasty 1420 A.D.). Although none of these latter works embodied important changes from the Pe Kung, the entrance of the canal and the site of the dam were shifted further up. It should be noted that the further the canal entrance was shifted upward, the deeper the canal cut into the side hill and consequently the harder became the work. Since the side hill in the King Valley is so steep and close to the river those is scarcely enough space left to have an open canal of ample capacity. Moreover, as the rocks of the side hill consist of conglomerates, breccias and shales, almost fragmental, the banks naturally break and

leak easily. This explained clearly why the former works were destroyed so frequently.

During the Tsing Dynasty, when one portion of the bank broke off, attempts were made to cut into the side hill, and large springs were found running out from places where the cutting was done. As there had been a long period of suffering from torrential flood of the King River this new discovery made those undertaking the work content with the small quantity of the spring supply and they closed the entrance of the former canal. The canal now in use is called Lungtung, (dragon cave). The former dam has never been restored. The lower portion of the latter canal still goes by the name of Cheng Pe Canal in memory of the two famous men who did these great works. The land which is irrigat d now by the spring supply is only about 35,000 mous.

Lately we have experienced many occurences of famine due to draught in Shensi and we hear the people constantly cry for rain. Thousands and thousands of people died of starvation when each famine occurred It is a great shame as well as a great pity to see the old irrigation work in ruins and not to try to re-establish it. In short in order to avoid famine as well, there is only one way, that is, TO RE ESTABLISH THE CANAL CONSTRUCTED.

After the last great famine in north China was over, friends and people of this province decided to undertake this great work immediately. Conferences were held frequently by the representatives of the people from the Wei-peh District in consequnce where of Relief Committees were created both in Sian-fu and Sanyuan, and the Board of Wei-peh Irrigation Work was formed. Actual work on the surveys for reconstructing the irrigation system was started in October 1922, and the details of the results are given in the following pages. It is, however due specially to the warm sympathy of the people in this province and the earnest support of the International Famine Relief Committee, that the present accomplishment has been made possible. Therefore, before we go on to state our work in detail we wish to express our thanks to the parties just mentioned.



3 Distance measuring before Chung-shan

4 Sounding the old canal—lower course

5 Plane table work before Chung-shan

6. Side of cliff of Tiao-er-tsui; proposed location of irrigation tunnel entrance.

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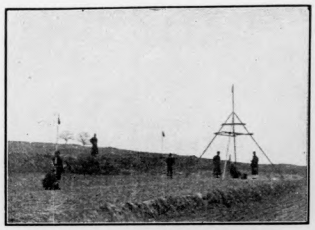

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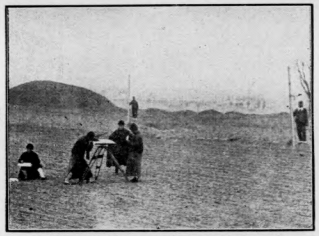

5 Plane table work before Chung-shan

6. Side of cliff of Tiao-er-tsui; proposed location of irrigation tunnel entrance.

II Descriptions of Tsung Shan and the King Valley

The Tsung Shan lies between the King and the Yeh Rivers, with Tso-O Shan in the east of the Yeh and Kiu-Chung-Shan in the west of the King, forming a natural barrier along the northern part of this province Near the King River those hills form a lofty ridge abo ut 470 m. above the bottom of the valley. Incidentally it may be said that behind these hills loess had been deposited nearly to the hill top forming high plateaus. Tsung Shan extends southward along the King River, and is known as the Chang-kia Shan where the rocks are limestones of eolithic appearance. These often have been used asconstruction material for the canal works. Towards the east the ridge forms a gap called Miao-Erling which is about 341 m. above the King River. Behind Mio-Er ling the course of the river makes a tongue-shapet sharp bend, between whicn the ridge is named the Tio-Er-Tsui, so called on account of its shape resembling a bird's beak. Before this hill a sloped higher loess land is formed and this has already been cultivated into terraces. The rocks of this hill are generally limestone, shales and sandstones and the strata struck N. 28° E and dipped at an angle of 60°.

The King River has its source from the Liu-Pan Shan which lies west of Ping-Liang-fu, Kansu and runs southeastward to Shansi. Before reaching Tsung Shan it receives many tributaries which makes its drainage area of about 42470 sq. km. Usually the river flows very calmly but during the rainy season of the year, it increases very rapidly, may be 100 times more than usual, thus threatening the people in the King Valley with flood nearly every year.

The bed of the river consists of blue limestone near Tio-Ertsui, then of white oolithic limestone a little down the stream and then of reddish shales near the entrance of the old canal. We find the same kinds of rocks on the hill sides, but the strata are more folded. The grade of the river bed is approximately 2: 1000. The river runs northwestward near Tio-Er-tsui and then bends straight to the south. After running off the head of the Hill, the valley widens suddenly. Instead

of rocky beds it then consists of sand, and gravel mixed with clayed materials. Banks on both sides are still very high and of an alluvial nature, due to deposition from the King. The top of the banks is covered with loess.

III Discussions on Methods Chosen for the Irrigation Works.

As we have said previously, if we want to avoid famine for this Province, there is only one way, namely to re-establish the old canal. In order to perform this great undertaking, there are two ways that can be followed and they are:

1. To keep the side hill canal system, and

2. To plan a more substantial water course; that is, to cut a tunnel through the hill. Of these two ways let us consider which is the better. Of course the first costs much less than the second. But considering the character of the rocks and the difficulty in keeping the banks from falling, we are influenced to prefer the second plan on account of the following advantages.

1. The tunnel way will be a straight and smooth passage for water so that the cross-section can be reduced and still provide an ample discharge quantity.

2. The location of the entrance will be much higher, so that it can irrigate more and wider lands.

3. The tunnel way could be made independant from the torrential floods of the King River.

4. There will be no fear of silting up from sediments and sloughing from materials from the hills.

5. The water supply can be easily controlled.

6. The maintainance cost, will be smaller.

As we have viewed the long and sad history of the old canal, we realize we should be very careful in choosing the method so as to obtain the greatest economy in the long run.

With the above reasons in view we decided first to make a preliminary survey. Let us summarize the scope of the surveying work that should be done as follows:

1. To survey the topography of Tsung Shan in order to detemine the axis of the tunnel and locations of other works.

7. Birds-eye view of the sharp bend of the King river at Tiao Er Tsui.

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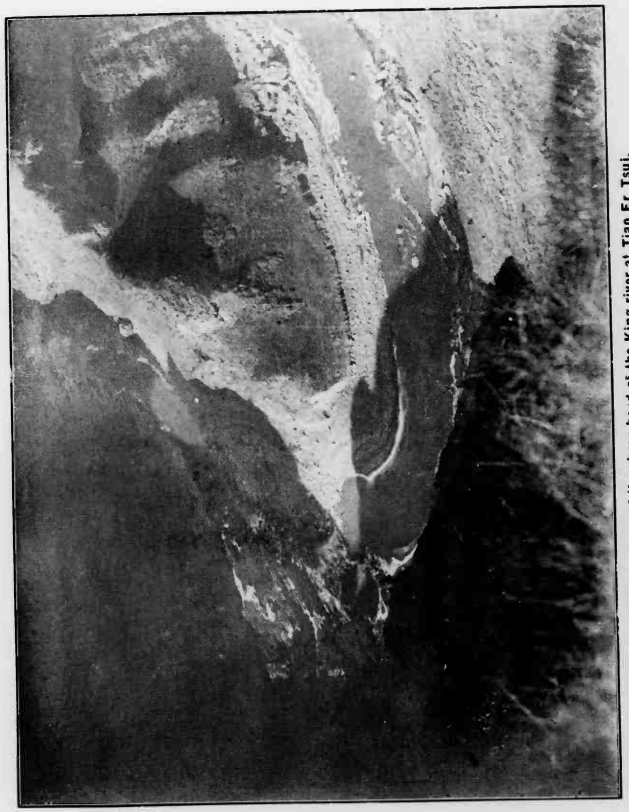


7. Birds-eye view of the sharp bend of the King river at Tiao Er Tsui.

2. To survey the topography of the King Valley in order to locate the dam site and the capacity of the reservoir.

3. To survey the land along the proposed main canal

4. To survey the old canals.

5. To survey the courses of other rivers which may have connection with the new project.

6. To observe the rainfall, evaporation, climate, etc.

7. To measure the discharge of the King and other rivers.

8. To study the goological features of Tsung Shan and the King Valley.

9. To study the agricultural conditions and methods to be adopted to get water in the fields.

10. To study materials of construction that can be obtained from the local places.

Of these numerous surveying tasks some have been finished, and some have only been commenced, as they are shown on the accompanying tables, maps and reports. However we hope to complete this preliminary work by the fall of 1924.

Before we enter the discussion of our new project, it is worth while to give a short statement about the old canal. The old canal is built on the left side hill of the King Valley, and its entrance is a little above a place where the river is extremely narrow, having only a width of 4 m. at low water. Although the narrow gorge is ten meters deep, it can hardly be acknowledged as a good site for a dam though traces of the ancient dam foundation work were found. Not far from its entrance, the canal runs through a short tunnel which is cut through a cliff, on top of which there is a temple called Lau-Lungwong-miao, about seven li from the Tio Er-tsui. When springs were found a little further down the stream from here, the canal was closed up below this temple.

The important springs are the Seh chue-tung, (cave of spreading pearls) and Kyung-chu-tung, (cave of pouring pearls.) The water quantity of these springs is more than 1 cum./sec; but on account of the irregularity of the canal and leakages on the embankment, it remains only 0.55 cum./sec. at the first turnout where the water begins to flow into the fields. Over

the Canal, there are many arched and plate bridges, most of which serve as waste ways for drained water from the land. However some of them are built so low that the water in the canal can not run through freely. In some places, along the left bank, stone dykes are constructed to retain sloughed materials from the hill slope. Only one part of the canal is in the rocks about 7 li long and the rest is all in muddy earth. From the start the canal is built parallel to the course of the King River, but when 8 li down from Lau-lung wong miao, it turns away at a place called San-hsien-tsia, (a sluice gate of three counties), it is then sub divided into three branches, one flows to San-yuan, one to Kau-ling and the third to King yong.

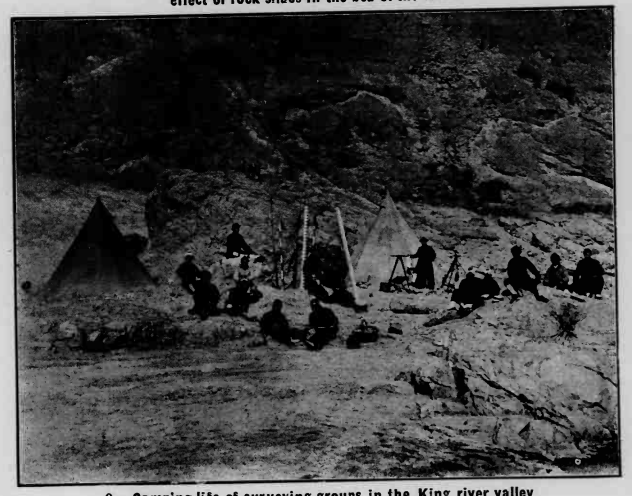
IV The New Project,

1. *Water supply.* The water-of the King River will be used as the chief source of water supply for the irrigation scheme. Other rivers will be made use of later when it is needed to increase the water supply. A main tunnel (we call it the irrigation tunnel) will be built from Tiao-Er tsui through the hill as the head way of the system. At the same time a shorter tunnel (we call it the culvert tunnel) will be built through the tongue-shaped ridge of Tiao-Er-tsui. After completion of this second tunnel the site of dams can be dried by diverting the river through it. Then we can first build a low dam below the entrance of the irrigation tunnel. When both the irrigation tunnel and the low dam are completed, the water can then be diverted through the former by closing the gate of the culvert for irrigation purposes. Then we can proceed to build a high dam below the low dam to transform the King. Valley into a large reservoir. Outside the irrigation tunnel a second reservoir will be made for equalizing the pressure and regulating the distribution of water.

2. *Distribution of water.* The old canal system will be enlarged and prolonged in order to distribute water to all the lands south of Tsingho. A main canal with branches will be constructed to cross many other rivers eastward with the purpose of irrigating all the lands possible north of Tsingho.

Wasteway. According to the experience gained this year the discharge of high flood of King River may be 100 times

8. On the right side of the King river about Tiao Er Tsui, showing the effect of rock slides in the bed of the river.



9. Camping life of surveying groups in the King river valley

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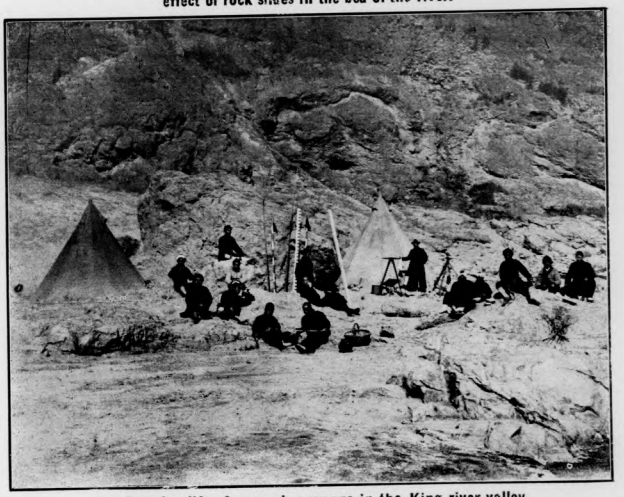


9. Camping life of surveying groups in the King river valley

that of the low water. Ample ways are therefore much needed for the safety of the dam. The culvert tunnel can discharge alone 60 cum./sec. Besides this the high dam must be provided with large spillways and ground outlets.

Sediments. The sediment brought by the King River consists of fine silt or boulders. The latter may be arrested by a small dam, on the upstreamside, while the former may be flushed through the ground outlets.

After the completion of the new project, the irrigable lands can be divided into two main territorial divisions, namely:

1. The Pe Kung Division which covers the region south of Tsin-ho with area of about 1,423,000 hectores or 215,792 acres

2. The Cheng Kuo Division which covers the region north of Tsing-ho with an area of about 2,972,000 hectores, or 460,675. acres. The work may be then divided into two steps as following:

First Step:

a. To construct the irrigation tunnel
b. To construct the culvert tunnel,
c. To construct a low dam to divert water from the King River into the irrigation tunnel.
d. To enlarge and repair the lower course of the old canal.

Second Step:

a. To build a high dam for storage,
b. To build the outside reservoir and dam.
c. To construct a new main canal and lateral canals, canal bridges, inverted siphons crossing other waters and other necessary canal structures. Let us now describe the steps separately.

First Step

a. To Construct the Irrigation Tunnel.

The tunnel find its entrance at a poiut below Tiao-Er-tsui and its outlet near Chou-kia gulley. It has a length of 2,560 m. and a cross-sectional area of 12 sq. m. The bottom of the tunnel entrance is at an elevation of 461 m. above sea level and its outlet at that of 460 m.; hence its grade will be 1/2560.

The tunnel will be excavated about 1,500 m. in rocks and 1,060 m. in loess. The axis at its entrance is about 3 m. above the level of the mean low water and 57 m. below the crown of the proposed high dam. The inside of the tunnel will be lined through out with cement mortar masonry works and coated smoothly. The velocity allowed in the tunnel is 5 m./sec (5 by 12 equals 60 cum./sec.). Above and down the tunnel sluice gates in vertical sbape should be provided, so that discharge can be controlled at will. The duplication of gates used here is for safety only. At the outlet of this tunnel an open-cut will be required near the Chau-kia Bridge and its deepest cut should be of 40 meters.

b. The Culvert Tunnel.

The culvert tunnel should be cut to pierce through the ridge of the Tiao-Er-tsui with a length of 400 m. Its purposes are:

1—To serve as an important waste-way for the floods of the King River, and

2—To make the dam site dry for construction.

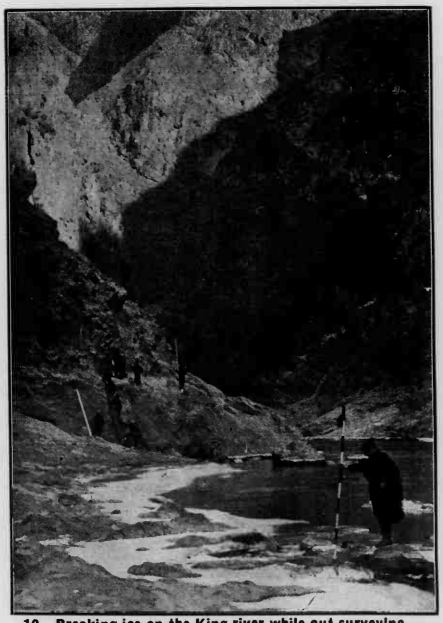
The cross-sectional area of this tunnel is of 12 sq.m. too and it can discharge the same quantity as the irrigation tunnel. The elevation of its bottom will be made below the low water level, and its inside should also be lined.

c. The Low Dam.

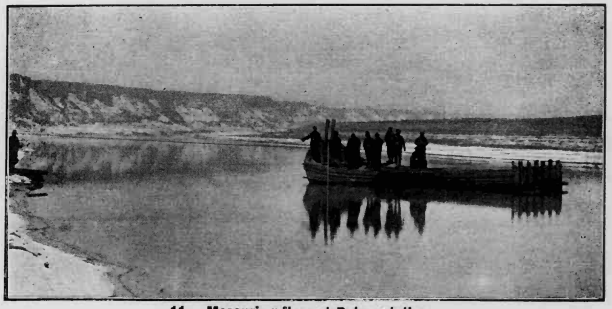
This dam should be built just below the entrance of the tunnel. The elevation of its crown will be the same as the top of the tunnel entrance, that is 465 m. The greatest height of the dam is 13 m, and the length is 100 m. It will be constructed with stones in cement mortar.

d. To Enlarge and Repair the Lower Course of The Old Canal.

From the outlet of the irrigation tunnel a stone-paved ditch will be dug in the open-cut to reach the old canal at the Chau-kia Bridge with a length of about 900 m. and a grade of of 14%. The Chua-hia Bridge should be reconstructed and an opening on top of the bridge and a tumble gate at the side near the King River should also be provided. When the gate which covers the opening is turned down water can then flow



10 Breaking ice on the King river while out surveying.



11. Measuring flow at Petun station.

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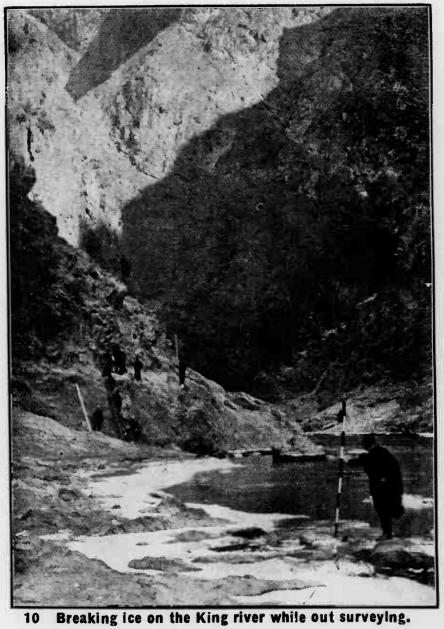

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11. Measuring flow at Petun station.

over the bridge into the King River. So it then forms a waste-way for surplus water. When the gate is raised, water then pours down through the opening into the old canal.

The capacity of the old canal is not enough to contain a quantity of water 30 times that of the canal discharge at present Toward the lower course it has been about silted up and retains no trace of its further course. It must therefore be enlarged and prolonged. As the survey of its course has not been completed, we can only state the work in a rough way. The total length to be enlarged and repaired may be about 120 km. and the stretch prolonged about 60 km. It must have a capacity to receive 15 cum./sec, discharge.

Second Step

a. To Build a High Dam for Storage.

The high dam will be constructed above the outlet of the culvert tunnel at the narrowest point of the valley. The bed rock here, (white oolithic limestone,) is compact and firm. The crown of the dam may have an elevation of 520 m. above the sea. It will be built in cyclopean concrete in an arched form. The length of the crown should be about 200 m. The capacity behind this dam will be of 80 million cum. or more.

The mean discharge of the King River according to the result of 8 months measuring can be assumed as 26.5 cum/sec. The amount of the extraordinary high flood is not considered. Basing on this we have then a monthly supply from the King River of 2,260,000 cum or a yearly supply of 788,400,00 cum. With 60% efficiency the water that can be actually used for irrigation may be increased to 473,000,000 cum.

The Hydraulic Scheme

In comparing the crown of the high dam with other important levels the elevation and difference of height are determined as follows:

Location.	Elevation in m.	Difference of height below the crown of the high dam in m.

Crown of high dam	520.00	0
Ordinary low water level	460.00	60.00
River bed (deepest place in the high dam site)	445.00	75.00
Bottom of the irrigation tunnel at the entrance	461.00	59.00
Bottom of the irrigation tunnel at the outlet	460.00	60.00
Top of Chan-Chia Bridge	446.00	73.25
Bottom of the old canal below Chan-Chia-bridge	442.55	77.45
Crown of outside reservoir dam	500.00	20.00
Bottom of the outside reservoir	458.00	62.00
Bottom of the main canal below head gate	480.00	40.00

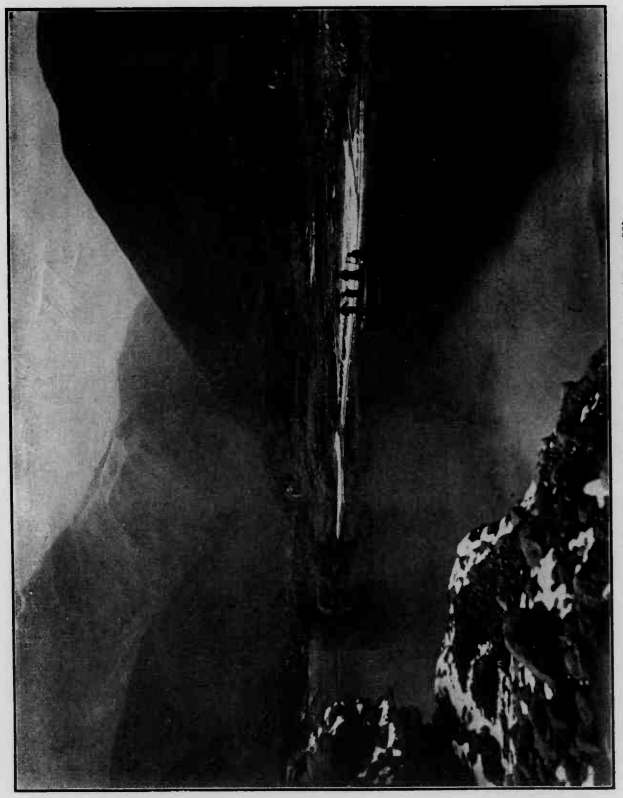
b. The Outside Reservoir and Dam.

The open cut before the outlet of the irrigation tunnel will be enlarged to 60m. wide and 275m. long. A stone dam provided with ground outlet and penstock opening will serve to close this cut. The bottom and walls will be paved and lined with stonework. It forms then the outside reservoir with a depth of 42m. Its capacity is a bout 700,000 cum. A head gate is also mounted at one side of the reservoir to connect the new main canal.

c. To Construct a New Main Canal.

The main canal must have a capacity at least 25 cum/sec. Its grade is of 1/10,000. The velocity is limited in this canal to 1 m./sec. On the front of the head gate the canal bottom has an elevation of 480m. It is below the lowest water level of the main reservoir of the King Valley,

The route of the main canal should follow that of the Cheng Kou Canal, instead of passing around the end of the high platean in the San-yuan district. It is most satisfactory to cut through this plateau at the norrowest place, called Wayao, so as to



12. Measuring discharge at Er Lung Wong Miao.

Crown of high dam	520.00	0
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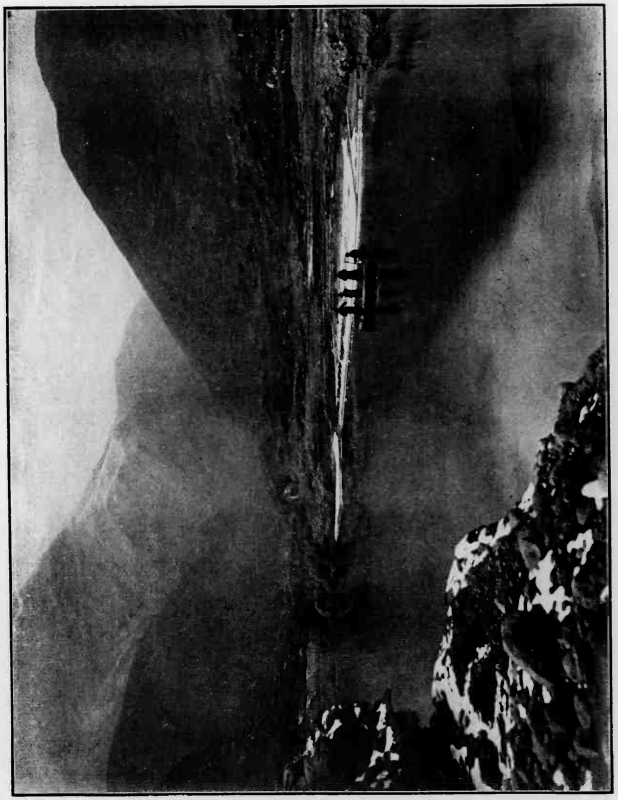


12. Measuring discharge at Er Lung Wong Miao.

enable it to cross the Shechuan River and to reach the aproach of Fuping city. It will then run east ward into the Lo River above Lung-yong.

Area to be Irrigated

The total irrigated area south and north of the Tsingho has been calculated to be about 4,390,000 mou or about 270,000 hectares and it can be divided into districts as:

King-yong and Li-Tsuan	622,018 *mou*,	San-yuan	393,522 *mou*
Lin-tung	681,293 *mou*,	Wei-Nan	1,096,553 *mou*
Fuping	410,947 *mou*,	Pucheng	570,589 *mou*
Tali	220,257 *mou*,	Whua	34,906 *mou*

Crops produced from the whole Weipeh district can be divided into the following three classes:

1. Winter crops, such as wheat, rape seeds, peas, lentils.

2. Summer crops, such as millet, maize, sweet potatoes, buck wheat, kaoliang, etc.

3. Spring crops, such as cotton, etc.

It is estimated that land occupied by winter crops would be one half of the total area of the district and the rest would be evenly divided between snmmer and spring crops.

Although no rainfall record in this province has been kept farmers simply remark the rainfall in the following expression.

1. One spate deep of rain corresponding to a rain fall from 10-20mm.

2. One plough deep of rain corresponding to a rain fall from 20-30mm.

3. Penetrated rain corresponding to a rain fall from 30-40 or 50mm.

For the crops generally one penetrated rain is very necessary before the planting of the seeds. The consumption of water is not much in winter, one plough deep of rain monthly during the growing time may be considered as enough, but much more in summer, twice or thrice this amount may be required.

Based on this consideration, we have established the following table of a hydraulic scheme, in which we have treated the Pe-kung Division separately because the discharge will serve at the same time for the electrical power station and therefore it is desirable that it be constant. The least storage in the main reservoir after a long period of usage is 1. 8 million cum. Water in all other rivers such as Yeh and Shechuan has not been considered but surely it will be an important addition to the supply when it is stored. We find then the existing water supply is quite enough for restoring both the Pe Kung and Cheng Kuo works.

Water power. The highest water level in the outside reservoir is 498. 50 m. the lowest level is 484.00 m. The fall between the reservoir level and penstock may be calculated:

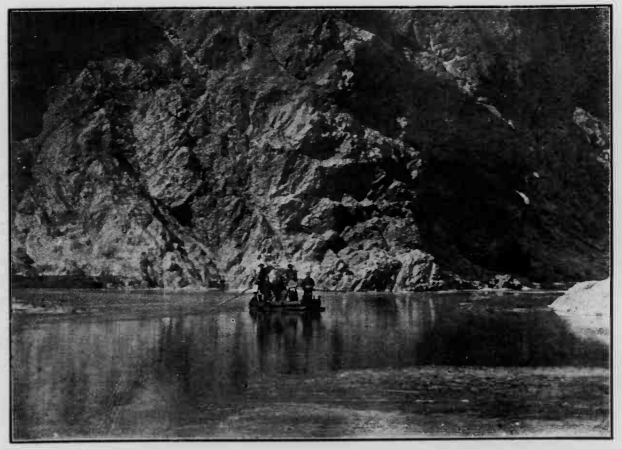
Max. 40. m.
Min. 25. 5m.
Average discharge is 8 cum./sec.
Therefore power can be derived

Max. 3200 H.P.
Min. 2040 H.P.

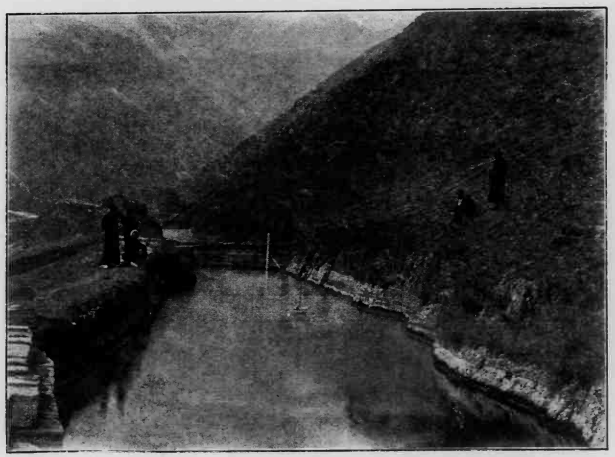
V. Results of the Preliminary Surveying.

According to the preliminary surveying plan as summarized under Discussions on Methods Chosen for Irrigation Works, we commenced our work in October, 1922 just after the formation of this Board. Down to the end of June, 1923, some of the surveying has been completed, some partly done. some just started, and some has not yet been touched. However, judging from the results of what we have done we are sure to have all the preliminary work finished about June or July 1924, if not earlier. Let us now sum up briefly the results as follows:

1. Traversing and leveling from B. M. O. across Miao-Erling to the side of King-River. A profile of this traverse line is drawn, from which the elevation of several important points are as follows:



13. Crossing the King river by boat in a deep canyon.



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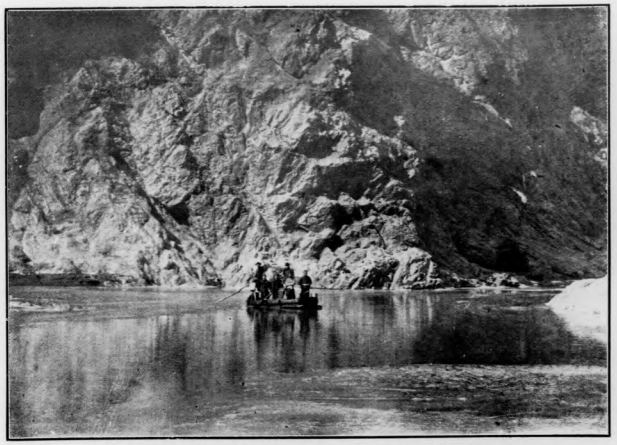

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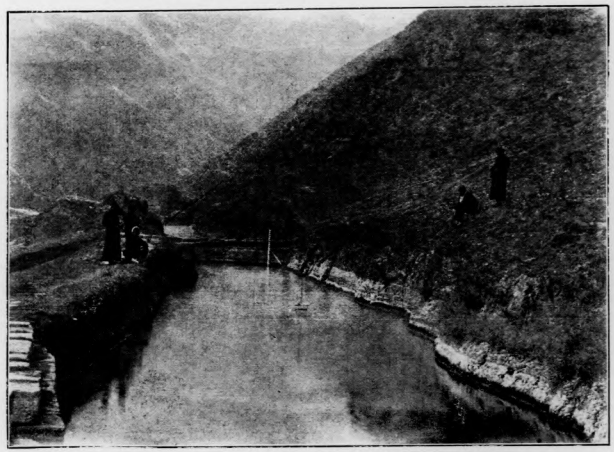

14. Measuring the discharge on the old Lung Tung canal.

B.M.O. at Yochiapo	500.00 m.
Water level of King-River during the time of surveying (it was an ordinary water stage)..	460.00 m.
B. M, on River side of the left bank..	460.92 m.
Highest point of the Miao-Er-ling	805.34 m.
Crown of the Chanchia-bridge..	446.70 m.
Bottom of the old canal under Chauchia-bridge	442 55 m.

This traverse line is 3. 9 km. in length; the direct distance between the two end points is 3154 m.

2. Topographic surveying of Tsung Shan. This is done by plane table work with alidade in connection with the traverses and triangulation points A plan with a scale 1/2000 was made, covering an area of 6.2 sq. km.

3. Surveying of the old canal. We divide this work in three sections:

A. From the mouth of Kuang-hai canal to the Yehu-bridge, 3.5 km. long totally in rock. Cross sectioning of the canal and longitudinal leveling of its bottom and water level were done. The canal in this section is very irregular both in shape and in depth, most parts being held by stone embankments in very dangerous positions.

B. From Yehu-bridge to Matao-bridge, 4 km long, along the river with very high embankments, traversed and leveled.

From Matao bridge to Shechiao chen, 10 km. in length totally in earth, taped and leveled. We are continuing this work now on the lower courses.

4. Surveying in the valley of King. Traversed along the the King-River and topographied with transits, from Er-lung-miao-up-stream 4000 m. long and from Er-lungwong-miao downstream to Petun 5000 m. long. Fifty cross sections are taken. A plan with scale 1/5000 is made.

5. Surveying of the main canal line. Traversed and leveled 110 km. and topographied 30 km. The plane table completed covers an area of 78 sq. m. The work is still continued.

6. Record of water stages, water gages were erected:

A. In King River at Petun discharge measuring station.

B. In King River at Er-lung wong-miao discharge measuring station.

C. In Lungtung Canal at Siao-wong bridge.

D. In Yeh River at Iolotan.

The zero point was referred from B. M. C. by taking levels.

7. Record of river discharge.

Two stations were established on the King River. The discharge is measured chiefly at the Petun station twice a week when the water stage is not changeable and daily when it is changeable in rainy season. Owing to the insuffioient equipment the discharge quantity of King River flood could not be measured directly but it might be estimated by rating curve.

8. Record of rain. We have constructed self registering rain gages of the Hellmann type. Three rain measuring stations are now established in the province and they are.

1. in Sian, established since January, 1923.
1. in San Yuan City, established since April, 1923.
1. in Yochia-po established since June, 1923.

9. The discharge of Lungtung Canal. As has been explained in the introduction the Lungtung Canal now is only fed by spring water. We measured the discharge of this canal at Siao-Wong bridge once every week and it gave an average value 1.15 cum/sec. We also measured it at Chouchia bridge, about 4 li, downward, and it gave only 0.75 cum/sec. The large loss of water is due to leakage and seepage at many places, the seepage in the section between Yehu bridge and Chouchia bridge being very noticeable. It has been planned to tighten this section and to close the leakage this winter.

10. Discharge through Wongwoo Turnour No. 1. This is the first Turnour through which the water of the canal begins to pour into the fields. When the time of irrigation comes the canal is totally closed by mud and the water runs through the Turnour. We measured the discharge through it, and got the result as 0.55 cum/sec. The irrigation took place once every

STAFF OF THE WEI-PEH IRRIGATION SCHEME, SHENSI.

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Yuan Ching-ting Yin Hui-chen Wang Yu-shan Li Ch'ung-san Fan Cho-fu Hu Jen-min Tsai Wei-jun

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D. In Yeh River at Iolotan.

The zero point was referred from B. M. C. by taking levels.

7. Record of river discharge.

Two stations were established on the King River. The discharge is measured chiefly at the Petun station twice a week when the water stage is not changeable and daily when it is changeable in rainy season. Owing to the insuffioient equipment the discharge quantity of King River flood could not be measured directly but it might be estimated by rating curve.

8. Record of rain. We have constructed self registering rain gages of the Hellmann type. Three rain measuring stations are now established in the province and they are.

1. in Sian, established since January, 1923.
1. in San Yuan City, established since April, 1923.
1. in Yochia-po established since June, 1923.

9. The discharge of Lungtung Canal. As has been explained in the introduction the Lungtung Canal now is only fed by spring water. We measured the discharge of this canal at Siao-Wong bridge once every week and it gave an average value 1.15 cum/sec. We also measured it at Chouchia bridge, about 4 li, downward, and it gave only 0.75 cum/sec. The large loss of water is due to leakage and seepage at many places, the seepage in the section between Yehu bridge and Chouchia bridge being very noticeable. It has been planned to tighten this section and to close the leakage this winter.

10. Discharge through Wongwoo Turnour No. 1. This is the first Turnour through which the water of the canal begins to pour into the fields. When the time of irrigation comes the canal is totally closed by mud and the water runs through the Turnour. We measured the discharge through it, and got the result as 0.55 cum/sec. The irrigation took place once every

STAFF OF THE WEI-PEH IRRIGATION SCHEME, SHENSI.

Wang Nan-hsuan Liu Chung-jui Hu Pu-ch'uan Li Pai-Ling Chang Tzu-lin
Yuan Ching-ting Yin Hui-chen Wang Yu-shan Li Ch'ung-san Fan Cho-fu Hu Jen-min Tsai Wei-jun

month and is continued for 7 hrs, giving a total quantity of 1271.4 cum. water. The fields irrigated consisted of 156 mous, and thus water consumed by each mou was 2.66 cum. But on account of incompletion of the irrigation method the water was more wasted than used.

11. Discharge of leaked water and under springs below the Lungtung Canal. We find there below the canal many water arms running into the King River. Some of them are due to leakage from the canal and some of them may be under springs. We measured the dischange of each of them.

12. Geological research. The rocks found in Tsung-shan and the King Valley are chiefly Limestones, some of which are white in color and of an oolithic appearance but some are of a dark blue color with a compact texture. The former can be used as construction material and are found in large blocks and the latter occur chiefly on the river bed. Other rocks found in the King Valley are reddish shales, conglomerates and breccias The rocks of Tsung-shan strike generally in the direction N 28° W and dip downward at an angle of 60°, but in the valley they are frequently folded. The rock material under the tunnel site and dam site require further research.

13. Temperature and barometric measurement. We recorded the temperature and atmospheric pressure daily.

VI. Estimate of the cost of the work in the first step.

As indicated before, the work of irrigation may be done in two steps. Since the necessary preliminary work is not quite finished, we can only furnish the design and estimate for the first step. For the second step we must wait until the preliminary work is all done.

A. Irrigation Tunnel:—2560m long, 1500m being in rock and 1060m being in loess. The cross sectional area of the finished tunnel is 12 sqm; the excavated cross sectional area is 13 sqm in rock and 17 sqm in loess. Volume of rock excavation is 19500 cum. Volume of loess exacavation is 18000 cum. The rock section will be lined with concrete, 10 cm thick, whilst the loess section will be lined with masonry work 1/2m thick.

Volume of concrete lining is 1500 cum. Volume of masonry lining is 5300 cum.

From this we have costs as follows:— M$

Rock excavation at $2.00 per cum..	39,000.00
Loess excavation at $0.55 per cum..	9,900 00
Timbering (only used in places where needed).. ..	10,000.00
Concrete lining at $40.00 per cum..	60,000.00
Masonry lining at $22.00 per cum..	116,600 00
9000 labor days for material hauling at $0.50.. ..	4,500 00
A Shaft in loess 100m deep..	500.00
A gate shaft in rock 56m deep with portal and wing wall.	5,400.00
The portal on the mouth of the tunnel with wing wall	3,000 00
Two gates with operating mechanism	15,000.00
Compressed air plant.	100,00 .00
Pumps, cranes and other small machinery..	50,000.00
Tracks, cars, drills and other tools.	50,000.00
Total	$463,900.00

B. Culvert tunnel:—400m long, without lining

Rock excavation. 3400 cum at $2.00 per cum.. ..	6,800.00
A shaft with portal and wing wall..	5,400.00
Gate including operating mechanism..	7,500.00
Total	$ 19,700.00

C. Low dam:—

Foundation work.	60,000.00
Masonry work, 7000 cum in volume at $20 .00 per cum	140,000.00
Temporary dam for diverting water	5,000.00
Cahle way over the river..	1,500 00
Total	$206,500 00

D. Open excavation outside of the main tunnel:—900 m long from the tunnel mouth to Chauchia-bridge should be excavated in open cut one section 100m in length should be cut 15m wide with an average depth 32m. Other section 800m in length, should be cut 8m wide with an average depth 20m. A canal 4m wide on top, 2m wide on bottom and 2m deep dug on the bottom of the open cut.

Earth excavation, 184,500 cum at $0.30	55,350.00
Stone pavement at $20.00 per cum (1300 cum).. ..	26,000.00
Reconstruction of Chauchia-Bridge as sluice way ..	5,000 00
Total	$ 86,350.00

E. Enlargement of the old canal system:—

Enlarging 120 km long canal at $500 00 per km.. ..	60,000.00
Prolonging the canal for a distance of 60 km at $1250.00 per km..	75,000.00
Purchasing of ground 15000mou, $20.00 per mou.. ..	30,000.00
Total	$165,000.00

F. Office expenses, at $200.00 per month for four years 9,600.00

Buildings, yards, shops etc	5,400,00
Agents,, travelling etc..	6,800.00
Miscellaneous, lamps, fuel, oil etc. at $500 per month	24,000.00
Road construction..	1,200.00
sum.....	$ 47,000.00

Total sum:—

M. $	463,900.00
	19,700.00
	206,500.00
	86,350.00
	165,000.00
	47 000 00
M. $	988,450.00

With 25% added for contngencies it gives total of M$1,235,562.00

———

TABLE 1

	Months		Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Annual Sum	Remarks
	I. Water Consuption															
	The period of irrigation and the water height required in field in m.m.	Winter Crop	50*	40	40			40		40**					210	*Time of sowing **Time of end of the growing
		Summer Crop	40*										80*	60	180	
		Autumn Crop								50*	40		60**		150	
	The consumption of water in field in Mill. cum.	Per day	3.15	1.80	1.80			1.80		2.92	0.9		3 0	1.20		
		Per month	94.5	54.0	54.0			54.0		87.7	27.0		93.00	37.2	501.4	
A	The constant discharge of 8 cum. sec through the lower gate of outside reservoir in mill cum.	Per day	0.69	ditto	ditto	ditto	ditto	ditto	ditto	ditto	ditto	ditto	ditto	ditto		This constant discharge serves to develop power and then irrigate the Pekung-Sec. 1423000 cum.
		Per month	20.7	21.4	20.7	21.4	21.4	1.93	21.4	20.7	21.4	20.7	21.4	21.4	252.3	
B	Monthly consumption of water in the Chang-kou Section in Mill cum.	Nett Need	64.0	36.6	36.6			36.6		50.2	18.3		63.8	27.5	342.6	Consumption of water in field
		Gross need	106.6	61.0	61.0			61.0		98.5	30.5		106.6	45.8	571.0	Above value divided by 0.60
C	Consumption of water by evaporation in the canal during the non-irrigation period in mill cum.					0.05	0.05		0.10			0.30			0.50	Evaporation of water in the canal
	Sum of A — B — C		127.3	82.4	81.7	21 9	21.9	80.5	21.5	119.2	51.9	21.0	128.0	67.2	823.8	
	II. Water Supply															
D	Monthly mean discharge of King River in cum Sec.				27.38	15.49	17.00	16.00	36.00	33.00	24.06					Measured
			40	25								16.5	40	30		Estimated
E	Water Supply from King River in Mill cum.	Per day	3.46	2.16	23.6	13.4	1.47	1.38	3.11	2.85	2 08	1.38	3.46	2.50		
		Per month	193 8	67.0	70.8	41.5	45.6	38.6	96.4	85.5	64.5	41.5	107.2	80 3	842.7	
	Comparison Between D and E	Surplus				19.6	23.7		74.9		12.6	20.5		13.1	18.9	
		Deticiency	23.5	15.4	10 9			41.9		33.7			20.8			
	Storage in the reservoir in Mill cum.		44.5	29.1	18.2	19.6	43.3	1.4	76.3	42.6	55.2	75.7	54.9	68.0		

This table was made before the end of June, 1923. The Monthly mean discharge of June and July measured later is not far from this guesswork, if the extraordinary high flood of last July is not considered.

TABLE 2.

The change of water level of King River, Yeh River and Lungtung Canal.

Rivers	Location		1922		1923						
			Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July
King	Petun	max.	0.43	0.31	0.35	0.48	0.63	0.74	0 58	0.25	8.40
		min.	0.12	0.10	0.12	0 18	0.44	0.30	0.24	0.10	0.20
		mean.	0.35	0.21	0.24	0.37	0.58	0.49	0.40	0 15	2.58
		max.	0.80	0.86	0.88	1.00	1.08	1.08	1.08		
		min.	0.70	0.68	0.76	0.80	1 00	0.92	0.78		
		mean.	0.75	0.79	0.80	0.84	1.01	1.02	0.98		
Yeh	Locotun	max.	0.46	0.53	0.55	0.58	0.40	0.41	0.42		
		min.	0.39	0.39	0.39	0.38	0.35	0.36	0.32		
		mean.	0.42	0.46	0.46	0.43	0 39	0.39	0.375		
Lungtung Canal	Siaowong bridge	mix.	1.37	1.39	1.47	1.44	1.58	1.75	1.76		
		min.	1.30	1.35	1.32	1.34	1.44	1.58	1.75		
		mean.	1.34	1.37	1.40	1.39	1 53	1.64	1.755		

TABLE 3.

Discharge of King River in cum./sec.

Year	1922			1923					
	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July.
max.	28.393	16.329	20.550		45.908	58.004	37.455	17.50	1050.00
min.	26.510	14.631	13.202		28.747	23.262	15.635	10.00	12.50
mean.	27.380	15.487	17.004	16.003	36.840	33.007	24.061	13.80	500.00

Mean discharge of other rivers measured during the ordinary water:

Yeh 2.00 cum./sec.
Tsing 1.15 cum./sec.
Tsoe 0.18 cum./sec.

TABLE 4. Rainfall in 1923 in mm.

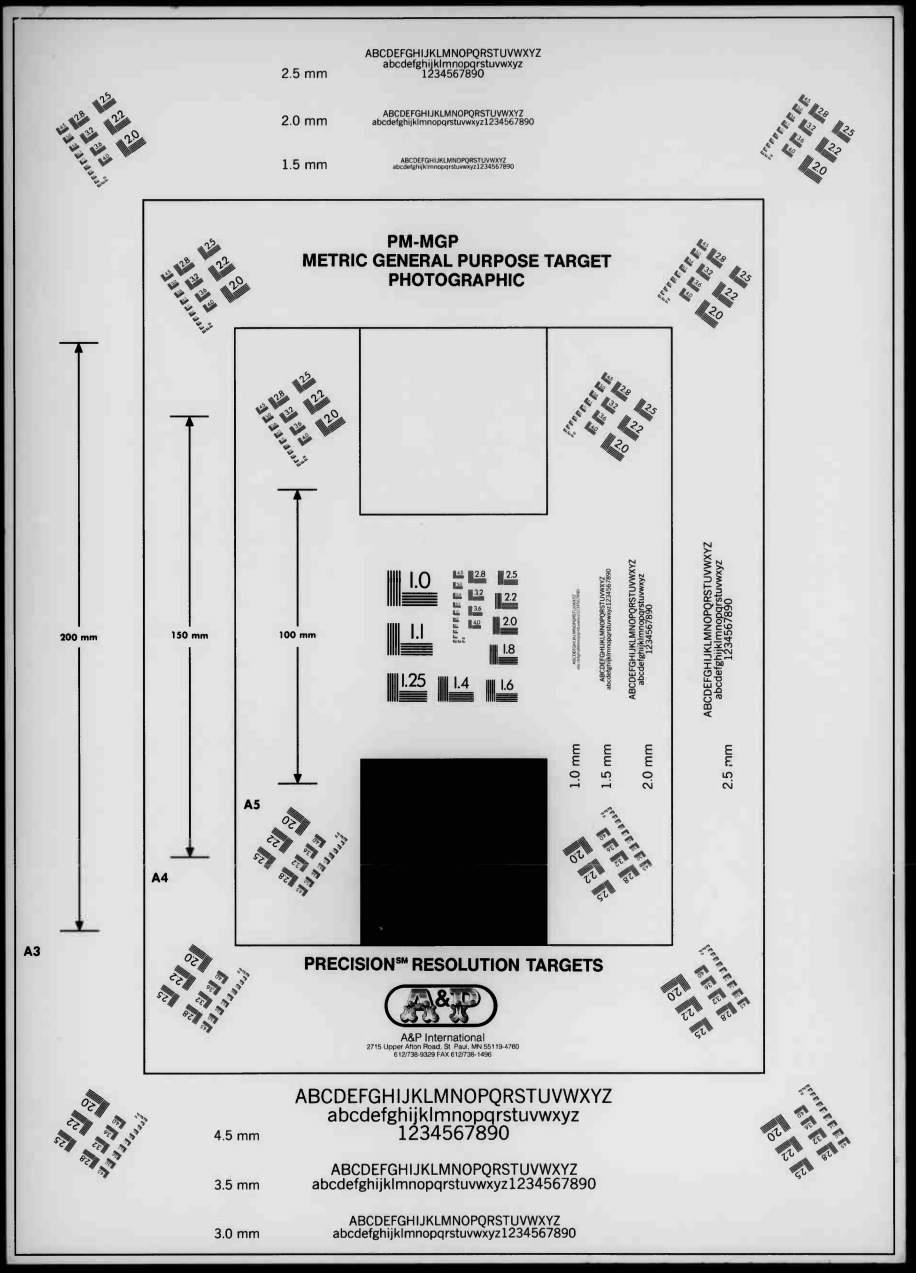
Months	Jan.	Feb.	Mar.	Apr.	May	June	July
Sianfu	5.6	5.5	9.0	60.5	44.0	70.0	105.0
Sanyuan				16 5	41.0	24.9	104.8
Yochiapo						25.5	74.0

TABLE 5.

The discharge of leaked water and under springs below the Lungtung Canal.

地名	Locality	Character	Discharge in cum./sec.	Mathod of measurement used & Remarks
天姥池下	Under the Tienlanche	Spring	0.2622*	by current meter already closed
背弓井	Pekungtsing	Leakage	0.1221*	
大退水槽下	Below the wastegate No. 1	,,	0.0085	by Weir
明玉泉	Ming-Yue-Spring	Spring	0.0524	
到流泉西下	Below Tan-Lin spring	,,	0.1176*	
王御史渠口南端六水	6 Springs south of the mouth of W.Y. Canal	,,	0.1227*	
小暗橋西	West of Siao-An bridge	Leakage	0.0003	All below are measured by direct Methods
大退水槽北	North of wastegate No. 1	,,	0.0006	
大王橋西南	South west of the Ta-Wang bridge	,,	0.0002	
大王橋西北	North west of the Ta-Wong bridge	,,	0.0002	
大王橋西端	West of Ta-Wang bridge	,,	0.0001	
明玉泉鉄筒	Ming-Yue spring iron siphon	,,	0.0003	
明玉泉北	North of Ming-Yue spring. 1 & 2	Spring	0.0033	
明王泉北	North of Ming-Yue spring 3	,,	0.0040	
王御史渠口南	South of W.Y. Canal entrance 1	,,	0.0024	
王御史渠口南	South of W.Y. Canal entrance 2	,,	0.0037	
王御史渠岩隙	Fissure in the entrance of W.Y. Canal	,,	0.0018	
碌牆溝	Lutu-Gully	,,	0.0008	
到流泉下南	South of Tau-Liu spring 1	,,	0.0017	
到流泉下南	South of Tau-Liu spring 2	,,	0.0010	
到流泉下北	North of Tau-Liu spring	,,	0.0004	
老龍王廟後	Behind Lau Lung Wang Miao	,,	0.0063	
總計	Total	,,	0.7125	

REDUCTION RATIO 18:1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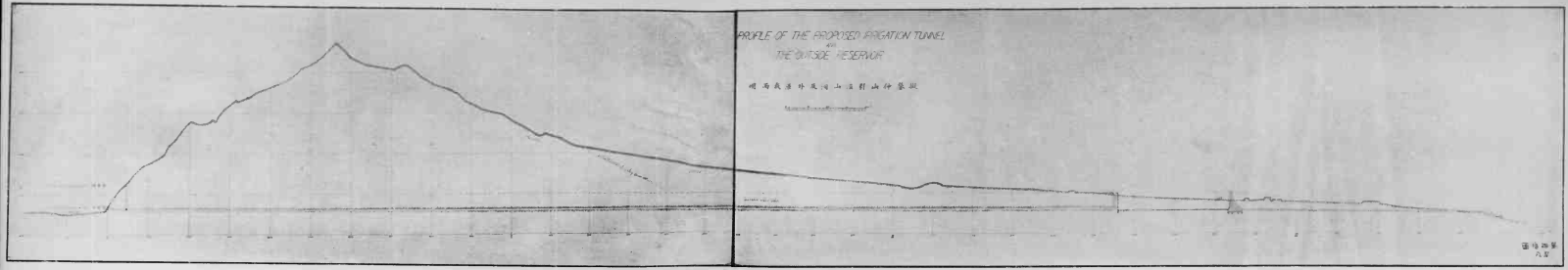
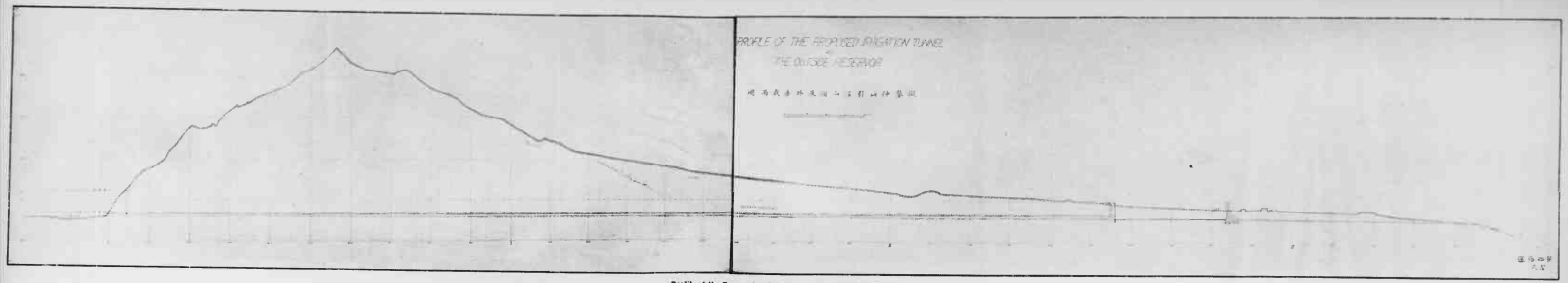


Profile of the Proposed Irrigation Tunnel and Outside Reservoir



Profile of the Proposed Irrigation Tunnel and Outside Reservoir

REDUCTION

RATIO

10:1

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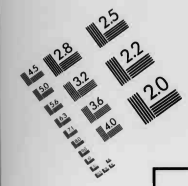

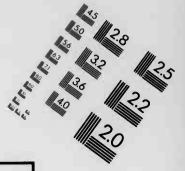

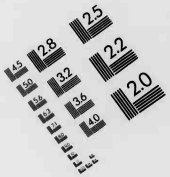

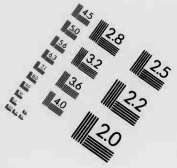

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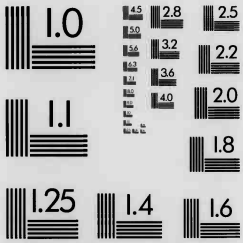

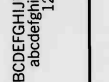

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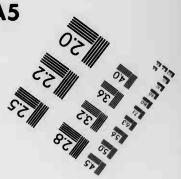

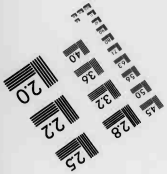

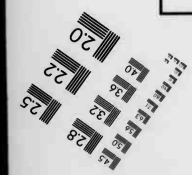

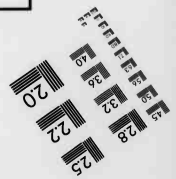

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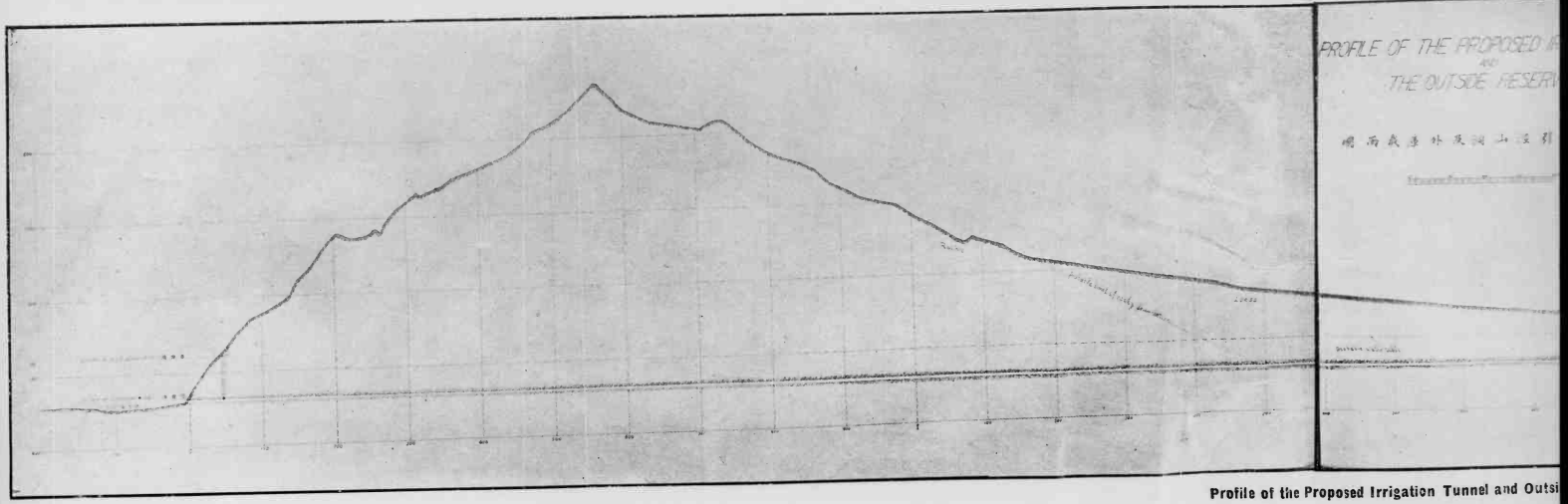

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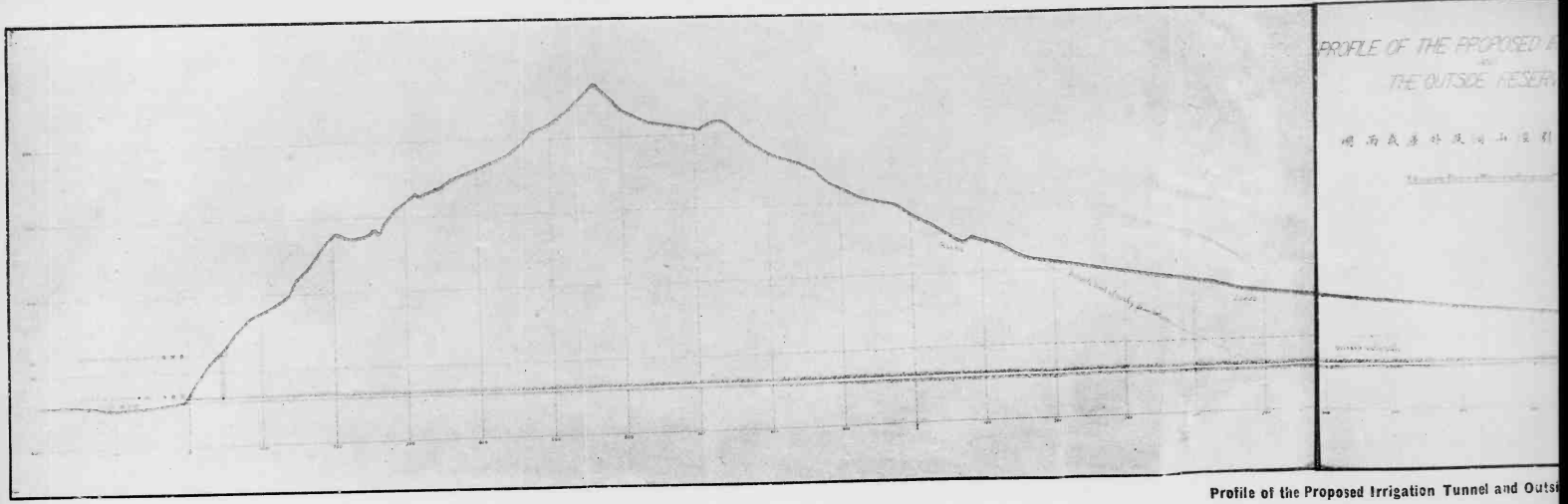

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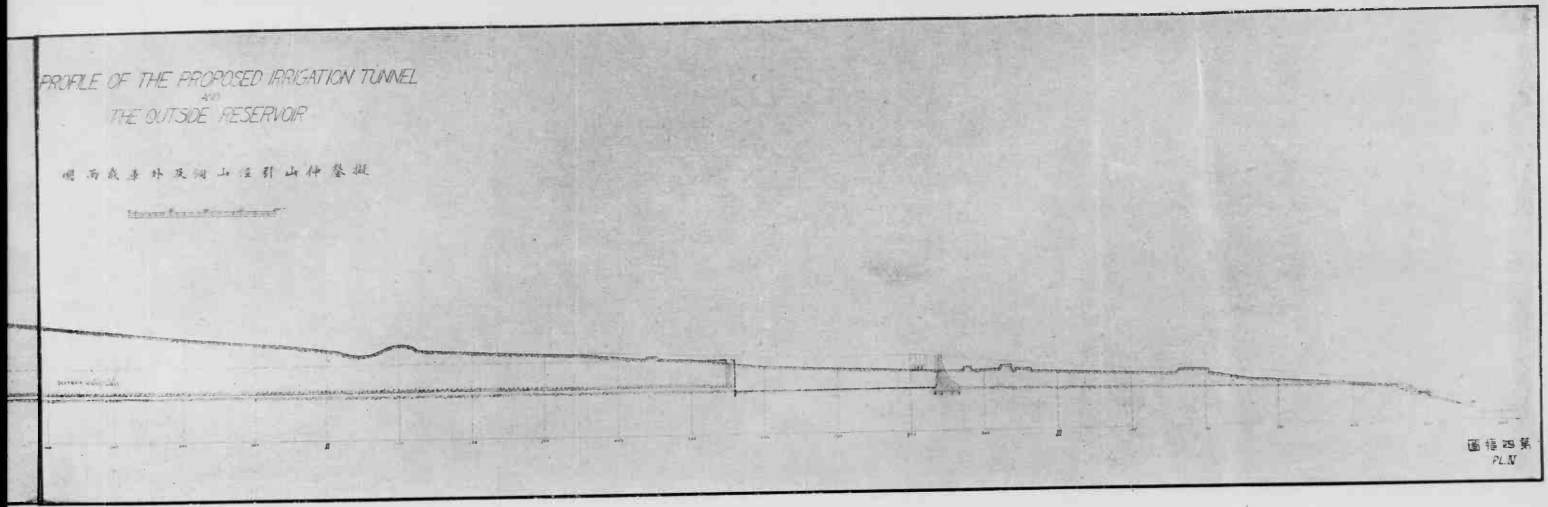

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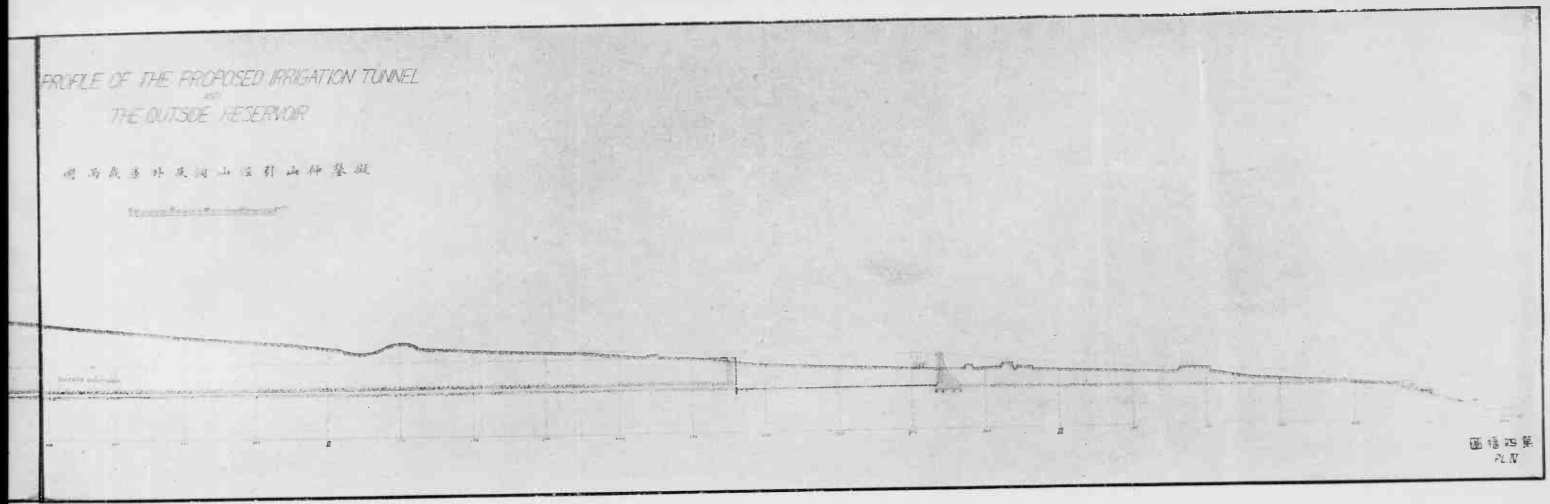

he Proposed Irrigation Tunnel and Outside Roservoir

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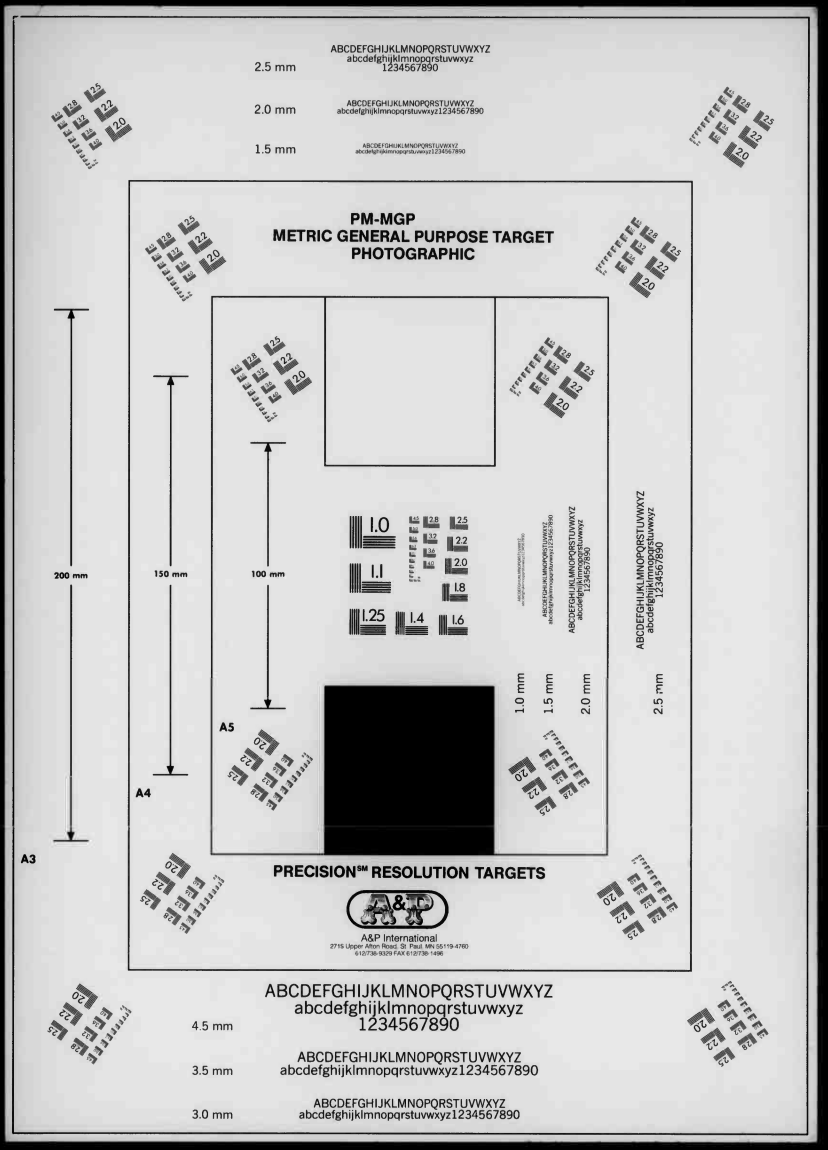
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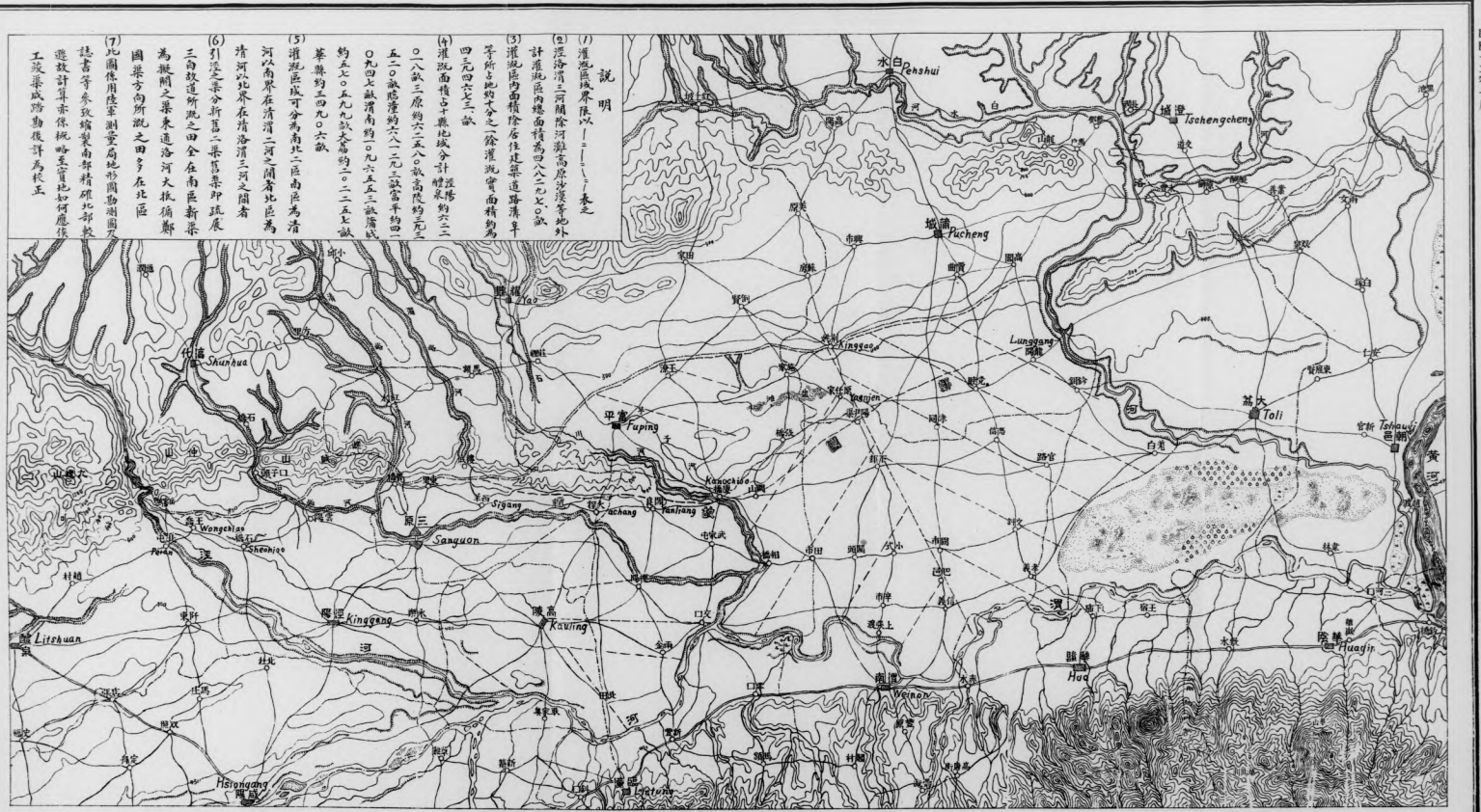
渭北灌溉區域圖

The Weipeh plane Showing The Limit of Irrigable lands



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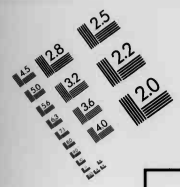
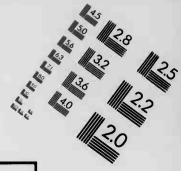
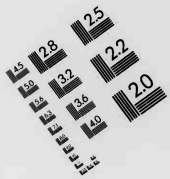
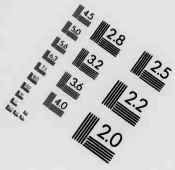
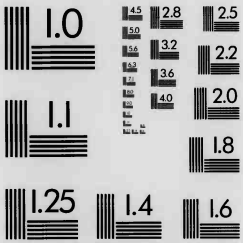
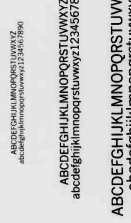
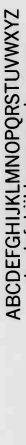
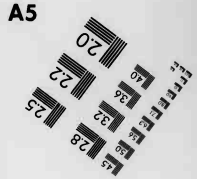
PM-MGP
METRIC GENERAL PURPOSE TARGET
PHOTOGRAPHIC

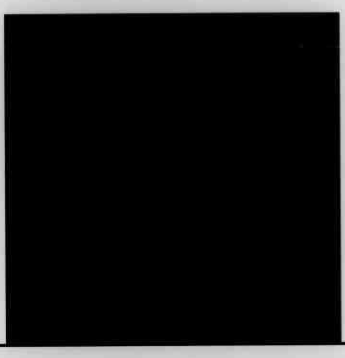
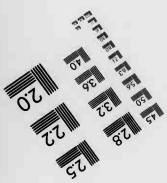





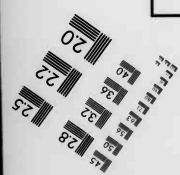
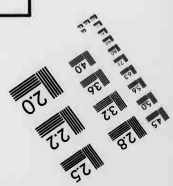








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渭灌區域圖

The Weipeh plane Showing Th

說明

(1)灌溉區域界限以一一二一二一表之

(2)涇洛渭三河間除河灘高原沙漠等地外計灌溉區內總面積為四八二九七、〇畝

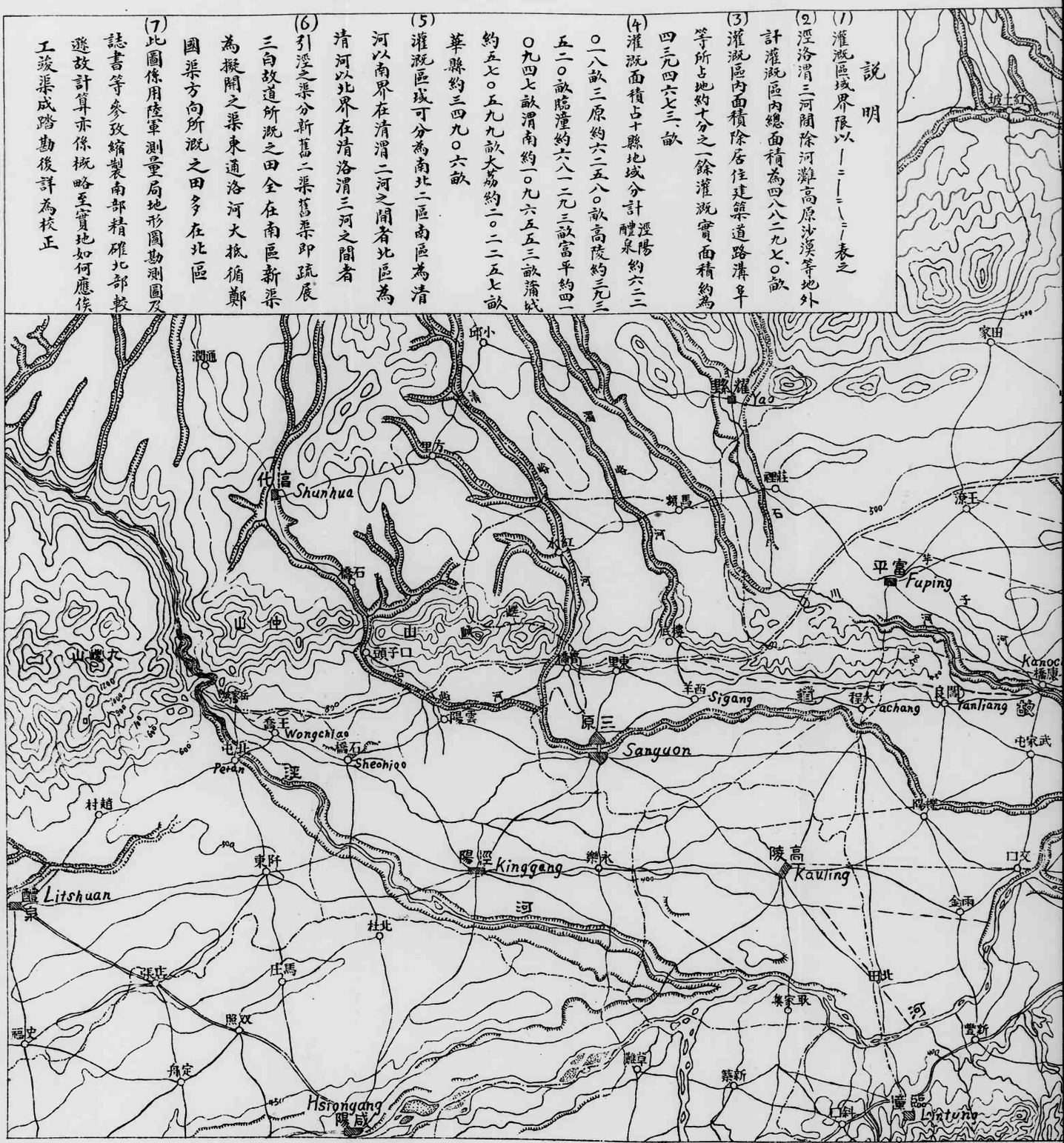
(3)灌溉區內面積除居住建築道路溝阜等所占地約十分之一餘灌溉實面積約為四三九四六七三、畝

(4)灌溉面積占十縣地域分計涇陽醴泉約六二二〇一八畝三原約六二五八〇畝高陵約三九三五二一〇畝臨潼約六八一二九三畝富平約四一〇九四七畝渭南約一〇九六五三畝蒲城約五七〇五九九畝大荔約二〇二二五七畝華縣約三四九〇六畝

(5)灌溉區域可分為南北二區南區為清河以南界在清渭二河之間者北區為清河以北界在清洛渭三河之間者

(6)引涇之渠分新舊二渠舊渠即疏展三白故道所溉之田全在南區新渠為擬開之渠東通洛河大抵循鄭國渠方向所溉之田多在北區

(7)此圖係用陸軍測量局地形圖勘測圖及誌書等參攷縮製南部精確北部較遜故計算亦係概略至實地如何應俟工竣渠成踏勘後詳為校正



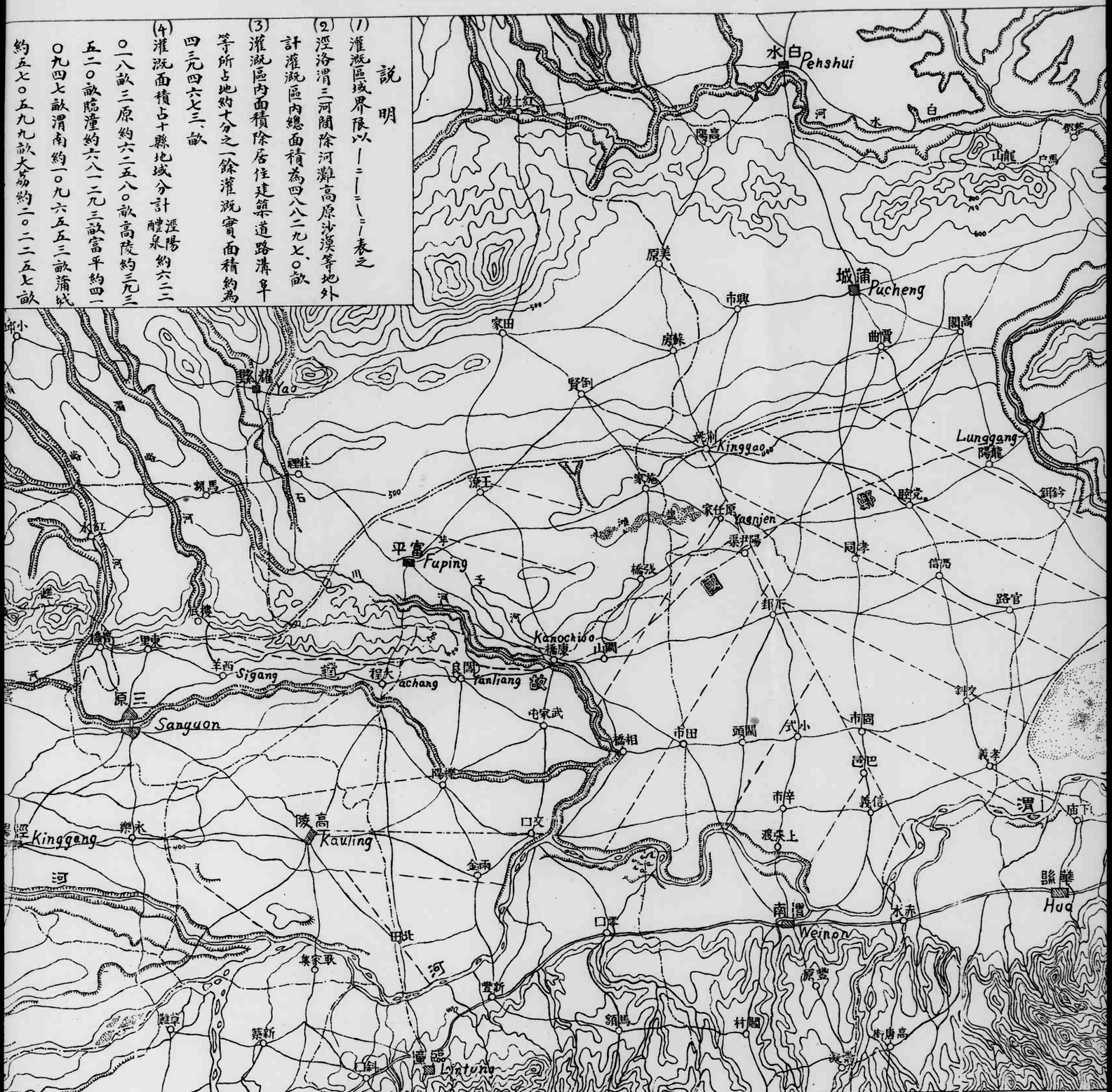
果林 沙漠 部落 鎮市 縣治 縣界

分一之尺

渭北水利工程局製

渭北灌溉區域圖

The Weipeh plane Showing The Limit of Irrigable lands



渭北灌

mit of Irrigable lands

民國十二年七月

標高自岳家坡假定
哀以五百公尺起算

REDUCTION RATIO 14:1

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz
2.5 mm 1234567890

2.0 mm ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz1234567890

1.5 mm ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz1234567890

PM-MGP
METRIC GENERAL PURPOSE TARGET
PHOTOGRAPHIC

200 mm

150 mm

100 mm

A5

A4

A3

1.0 mm

1.5 mm

2.0 mm

2.5 mm

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ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz
4.5 mm 1234567890

ABCDEFGHIJKLMNOPQRSTUVWXYZ
3.5 mm abcdefghijklmnopqrstuvwxyz1234567890

ABCDEFGHIJKLMNOPQRSTUVWXYZ
3.0 mm abcdefghijklmnopqrstuvwxyz1234567890

釣兒嘴飛勢平面圖
引涇鑿洞之計畫

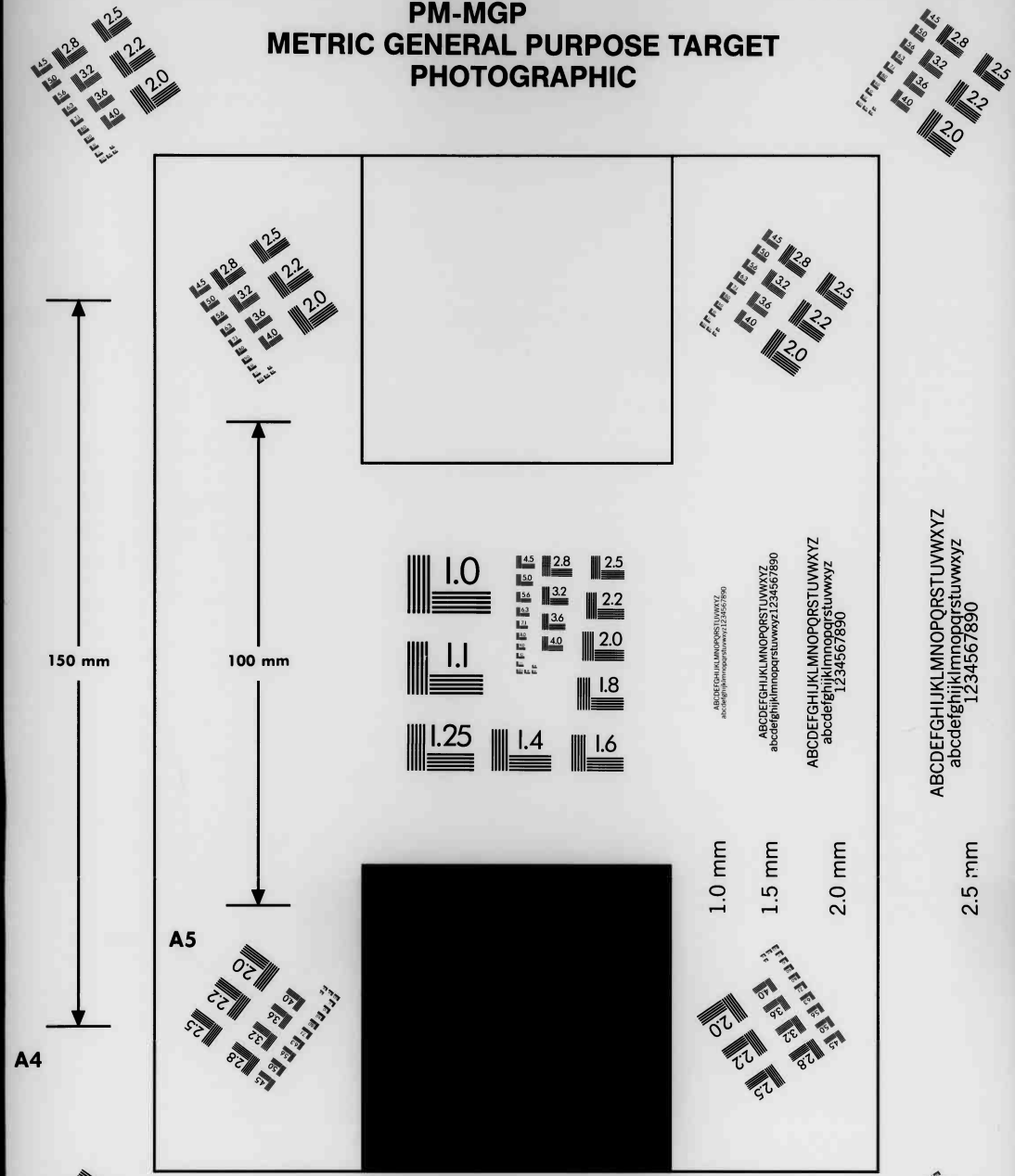
1/10000

TOPOGRAPHIC PLAN
OF
TIAO-ER-TSIN
Tunnel Projection
OF
The Wepeh irrigation Work
Mode November 1922 to January 1923
Scale: 1/10000 or 1cm=1oom

(縮小)
第二幅圖
PL II

REDUCTION RATIO 10:1

PM-MGP
METRIC GENERAL PURPOSE TARGET
PHOTOGRAPHIC



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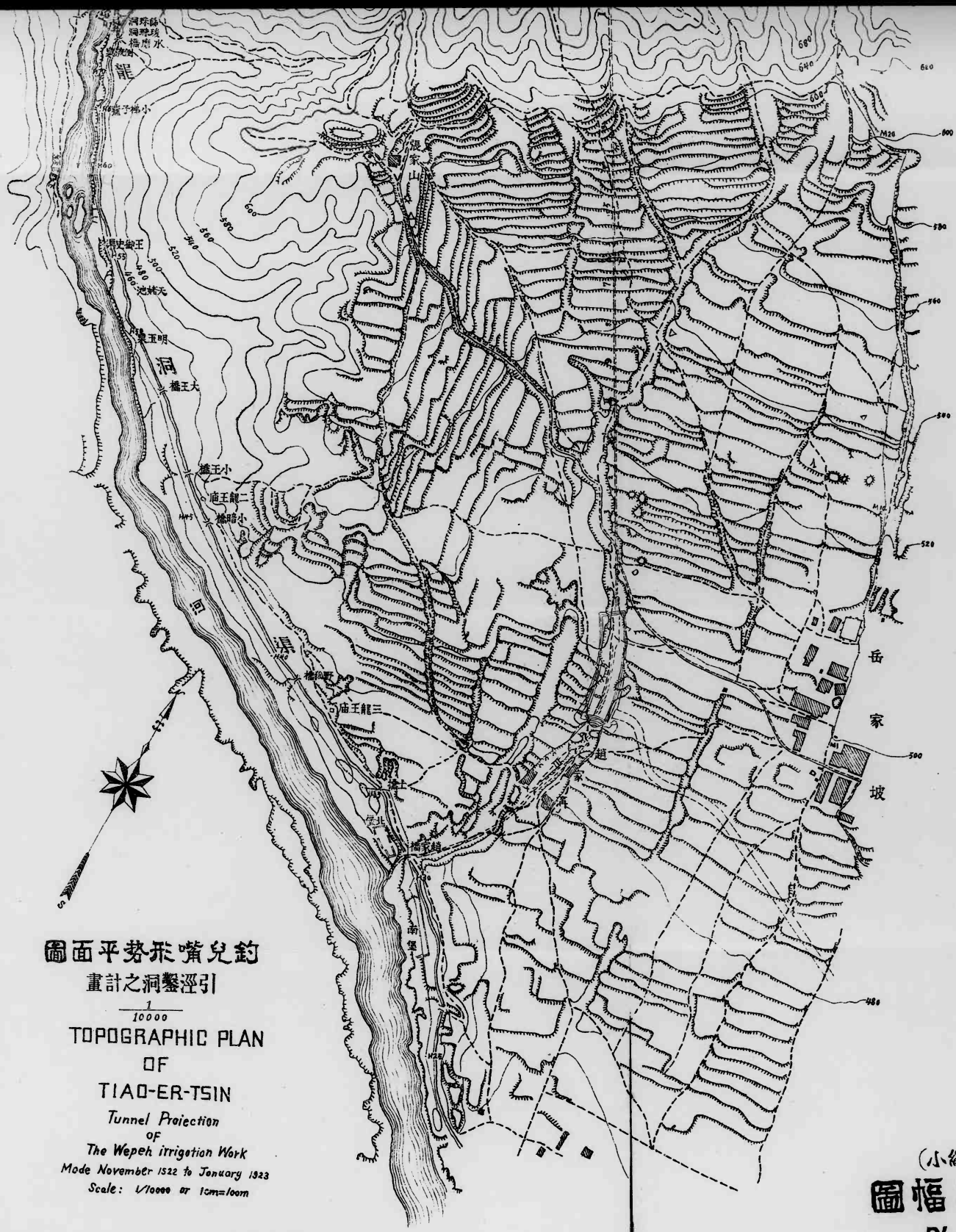
金口老龍王廟
龍
小橋子
溫家山
洞
大橋王
小橋王
二龍王廟
小橋賠



釣兒嘴形勢平面圖

引涇鑿洞之計畫

1/10000

TOPOGRAPHIC PLAN
OF
TIAO-ER-TSIN

Tunnel Projection
OF
The Wepeh irrigation Work
Made November 1922 to January 1923
Scale: 1/10000 or 1cm=100m

（小縮）

第二幅圖

PL II

END OF
TITLE